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Assessing energy security performance in the Asia Pacific, 1990–2010

Benjamin K. Sovacool*

Vermont Law School, Institute for Energy & the Environment, PO Box 96, 164 Chelsea Street, South Royalton, VT 05068-0444, United States

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ABSTRACT

Based on three years of research involving a literature review, interviews, surveys, and an international workshop, this study first conceptualizes energy security as consisting of the interconnected factors of availability, affordability, efficiency, sustainability, and governance. It then matches these factors with 20 metrics comprising an energy security index, tracking and scoring performance across 18 countries from 1990 to 2010. It lastly offers two case studies of Malaysia (most improved energy security over time) and Myanmar (worst improved) to provide context to the index's results before offering conclusions for scholars, analysts, and practitioners.

Contents

Introduction

Energy security concerns are rapidly rising in importance for countries in the Asia Pacific. China is now the world's largest emitter of greenhouse gases, responsible for about one-quarter of the world's total in 2008, and India has more than doubled its carbon emissions from 1990 to 2008 [1]. The International Energy Agency (IEA), the OECD's energy research body, forecasts the region's primary energy demand to grow at 2.5 percent annually over the next two decades, faster than the global average. With increased energy competition from titans like the United States and European Union, commodity price volatility, declining production from mature resource fields, and the costs associated with transitioning into a carbon-constrained economy, Asian countries will face several challenges in their paths to build energy infrastructure. Southeast Asia, for example, possesses about 1 percent each of the world's oil and coal stocks and less than 4 percent of total natural gas reserves [2]. Furthermore, about one billion people throughout the region live in "energy poverty" without reliable access to electricity or modern cooking fuels [3]. With such a diverse set of geographic boundaries, political systems, markets, and cultures, how ought energy security in the Asia Pacific be conceptualized, and how can national performance be measured and tracked?

This study explores the dimensions to energy security, measures it on a national scale, and presents particular case studies related to energy security in practice. It develops a comprehensive energy security index for use by analysts and scholars. After breaking energy security down into five interrelated concepts associated with 20 metrics, it measures the energy security performance of 18 countries – fourteen of them in Asia – from 1990 to 2010. It describes the countries that have most improved their energy security over this period, as well as those that have seen their energy security deteriorate.

* Tel.: +1 802 831 1053; fax: +1 802 831 1158.
E-mail addresses: Bsovacool@vermontlaw.edu, sovacool@vt.edu

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The value of such an approach is fourfold. First, focusing on energy security as a multidimensional concept helps to move away from narrow depictions as merely security of fuel supplies or appropriately priced energy services, to encompass areas transcending technology, efficiency, innovation, sustainability, stewardship, regulation, and governance. Second, proposing a systematic method of measuring energy security performance can inform energy policy and build institutional capacity. Analytical tools, such as indicators and empirically measurable metrics, are helpful in enabling analysts and regulators to find the best energy solutions in a portfolio of available options. Third, an energy security index makes it possible to correlate performance with major events such as military conflicts, embargoes, or the introduction of new, transformational energy policies or technologies. Fourth, an energy security index helps identify tradeoffs within the different dimensions of energy security and also areas needed for improvement.

Creating an energy security index

Why choose to develop an energy security index for the Asia Pacific? According to the most recent data available as of 2009, 1.4 billion people lack access to electricity, 85 percent of them in rural areas, and almost 2.7 billion people remain reliant on woody biomass fuels for cooking, numbers broken down in Table 1. An additional one billion people have access only to unreliable or intermittent electricity networks [4]. Put another way, the poorest three-quarters of the global population still only use ten percent of global energy [5]. Fifty-five percent of those without access to electricity globally as well as 72.3 percent of those dependent on traditional fuels globally reside in Asia—implying an urgent need to improve the energy security for a vast number of Asian countries.

Therefore, the author began by selecting eighteen countries to be assessed by an energy security index. The author chose the United States and the European Union (as its own entity) because they are the two of the world's most advanced energy producers and consumers, and serve as useful benchmarks; China, India, Japan, and South Korea because they are Asia's four largest energy consumers; and the ten countries comprising the Association of Southeast Asian Nations (ASEAN) (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) because they have rapidly developing economies. Australia and New Zealand were finally selected because they represent a diverse mix of energy importers and exporters and are also close in proximity to ASEAN.

With the countries selected, a five-phase research process was utilized that first involved (a) an extensive review of the academic literature, followed by (b) research interviews with energy experts, (c) a survey of energy planners, and (d) an international workshop to determine appropriate dimensions, components, and metrics [7]. Tables 2 and 3 summarizes these criteria.

With the index established, the next phase involved collecting data for these 20 metrics for the period 1990 to 2010 in five year increments. The author relied on energy databases and reports from the International Energy Agency, U.S. Energy Information Administration, World Health Organization, World Bank, and United Nations. As these sources did not provide complete coverage for all countries over the years in question, the author's team reviewed academic articles and reports for missing pieces of data. Energy ministries in the relevant countries were contacted via email, fax, and telephone to fill remaining data gaps.

After collecting and coding raw data, the author made all 20 metrics unidirectional, so that higher values corresponded with better energy security scores (the idea being that it would be easier to identify common trends). The author thus inverted or transformed eight metrics: price stability [8], households dependent on traditional fuels, retail gasoline prices [9], energy intensity, grid inefficiency, per capita CO_2 and SO_2 emissions, and per capita energy subsidies.

The final phase concerned scoring country performance among the 20 metrics over the 20-year period. Rather than measure performance using some type of abstract or absolute method, the author instead made scoring *empirical* and *relative*: empirical in that scores were based on real-world performance of countries observed within a particular metric for a given year, and relative in that we took the best and worst scores for those countries and used those to create our range of scoring points. This involved converting all of our data points to a score between 0 and 100 [10]. This means the scores for any given category shift year to year, and metric to metric; they are entirely dependent on the best and worst performance of actual countries, capturing the inherently comparative nature of energy security performance. Appendices 1 and 2 present the raw data as well as the results of the scoring exercise for all eighteen countries.

Assessing Asian energy security performance

If one takes the mean score for each year and metric and compares them over time, one gets a decent sense for who has most and least improved their energy security from 1990 to 2010. Fig. 1 depicts the overall percentage change (positive and negative) for all 18 countries from 1990 to 2010. Malaysia (31 percent), Australia (28 percent), and Brunei (28 percent) were the three countries who improved their energy security the most; Laos (−44 percent), Cambodia (−61 percent), and Myanmar (−63 percent) the three that saw their relative energy security decline the most. The remainder of this section showcases a case study of Malaysia (top performer) and Myanmar (worst performer).

Malaysia

Malaysia has made remarkable gains improving its energy security over the past two decades. As Tables 2 and 3 summarize, it has expanded access to electricity and modern energy services, lowered its energy intensity, maintained stable (though subsidized) energy prices, and improved the efficiency of its transmission grid, among others. It has done so through the implementation and enforcement of four major energy policy acts as well as careful investment in oil and gas production, and efforts to grow a local renewable energy industry.

In terms of availability, Malaysia is blessed with substantial reserves of fossil fuels—as Tables 4 and 5 document, it has the

Table 1
Number of people without access to electricity and dependent on traditional fuels [6].

	Number of people lacking access to electricity (millions)	Number of people relying on the traditional use of biomass for cooking (millions)
Africa	587	657
Sub-Saharan Africa	*585*	*653*
Asia	799	1937
China	*8*	*423*
India	*404*	*855*
Other Asia	*387*	*659*
South America	31	85
World	**1417**	**2679**

Table 2
Dimensions, components, and metrics comprising an energy security index.

Dimension	Component	Metric	Unit	Definition
Availability	Security of supply	Total primary energy supply per capita	Thousand tons of oil equivalent (ktoe)	Total primary energy supply comprises the production of coal, crude oil, natural gas, nuclear fission, hydroelectric, and other renewable resources plus imports less exports, less international marine bunkers and corrected for net changes in energy stocks.
	Production	Average reserve to production ratio for the three primary energy fuels (coal, natural gas, and oil)	Remaining years of production	Ratio of proven recoverable reserves at the end of a given year to the production of those reserves in that year.
	Dependency	Self sufficiency	% energy demand by domestic production	Percentage of total primary energy supply divided by total primary energy consumption.
	Diversification	Share of renewable energy in total primary energy supply	% of supply	Share of geothermal, solar, wind, hydroelectric, tidal, wave, biomass, municipal waste, and biofuel based energy in total primary energy supply.
Affordability	Stability	Stability of electricity prices	% change	Percentage that retail electricity prices have changed every five years.
	Access	% Population with high quality connections to the electricity grid	% electrification	Combined percentage of urban and rural electricity customers with reliable grid connections compared to all people in the country.
	Equity	Households dependent on traditional fuels	% of population using solid fuels	Percentage of the population that relies on solid fuels as the primary source of domestic energy for cooking and heating. Solid fuels include biomass, wood, charcoal, straw, crops, agricultural waste, dung, shrubs and coal.
	Affordability	Retail price of gasoline/petrol	Average price in US$PPP for 100 l of regular gasoline/petrol	Actual prices paid by final consumers for ordinary gasoline inclusive of all taxes and subsidies.
Technology development and efficiency	Innovation and research	Research intensity	% government expenditures on research and development compared to all expenditures	Expenditures for research and development are current and capital expenditures (public) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.
	Energy efficiency	Energy intensity	Energy consumption per Dollar of GDP	Total primary energy consumption in British Thermal Units per Dollar of GDP (2005 US dollars PPP).
	Safety and reliability	Grid efficiency	% electricity transmission and distribution losses	Electric power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage.
	Resilience	Energy resources and stockpiles	Years of energy reserves left	Reserves of coal, oil, gas and uranium divided by total final energy consumption.
Environmental sustainability	Land use	Forest cover	Forest area as percent of land area	Forest area is land under natural or planted stands of trees of at least 5 m in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.
	Water	Water availability	% population with access to improved water	Improved sources include household connections, public standpipes, boreholes, protected wells, and/or spring and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 l a person a day within one kilometer of dwelling.
	Climate change	Per capita energy-related carbon dioxide emissions	Metric tons of CO_2 per person	Annual tons of carbon dioxide emissions from fuel combustion divided by total national population.
	Pollution	Per capita sulfur dioxide emissions	Metric tons of SO_2 per person	Annual tons of sulphur dioxide emissions from fuel combustion divided by total national population.
Regulation and governance	Governance	Worldwide governance rating	Worldwide governance score	Mean score given for the six categories of accountability, political stability, government effectiveness, regulatory quality, rule of law, and corruption
	Trade and connectivity	Energy exports	Annual value of energy exports in 2009 US$ PPP—(billions)	Total value in US$ of net exports of coal (including coke and briquettes), crude petroleum, and natural gas (including liquefied natural gas).
	Competition	Per capita energy subsidies	Cost of energy subsidies per person (2009 US$ PPP)	Total government expenditures on direct and indirect energy subsidies divided by the national population.
	Information	Quality of energy information	% data complete	% of data points complete for this index out of all possible data points.

Table 3
Raw energy security data and adjusted energy security scores for Malaysia, 1990–2010.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio (years)	Self-sufficiency (%)	Share of renewable energy (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)
Raw data	1.2	–	2.2	16	–	–	–	150.7	–
1990									
1995	1.8	–	1.7	14	9	–	–	121	0.4
2000	2.0	–	1.6	19	−4%	97	–	83	0.9
2005	2.4	44	1.5	12	−9%	98	5	97	0.6
2010	2.7	50	1.3	9	8.0%	99	0	102	0.6
Scores									
1990	12.8	–	25.0	17.3	–	–	–	53.0	–
1995	20.2	–	22.1	14.7	30.3	–	–	33.3	11.1
2000	22.6	–	20.1	21.3	100.0	96.7	–	67.9	30.0
2005	30.9	17.7	17.7	13.6	100.0	97.5	94.7	55.8	18.2
2010	29.5	6.3	22.0	9.2	41.3	99.3	100.0	51.9	12.1

	Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related CO_2 (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP	Quality of energy information (completed data points)
Raw data	7,920	7	30	68	88	2.7	0.021	–	–	–	11
1990											
1995	7,617	9	30	67	92	3.8	0.021	66	–	–	14
2000	8,108	8	23	66	97	4.8	0.018	61	–	–	15
2005	16,596	1	16	64	100	6.0	–	64	35.8	172	18
2010	15,064	2	20	63	100	6.7	–	57	28.0	509	18
Scores											
1990	5.1	73.4	6.0	90.3	83.1	1.6	5.8	–	–	–	57.1
1995	9.8	78.6	8.7	90.8	87.3	1.3	5.0	64.5	–	–	50.0
2000	5.2	75.2	7.5	91.3	94.4	2.7	12.4	61.5	–	–	60.0
2005	16.4	96.2	6.0	90.5	100.0	1.8	–	65.5	35.8	3.0	50.0
2010	16.7	94.5	10.5	90.1	100.0	34.9	–	58.1	66.8	0.4	50.0

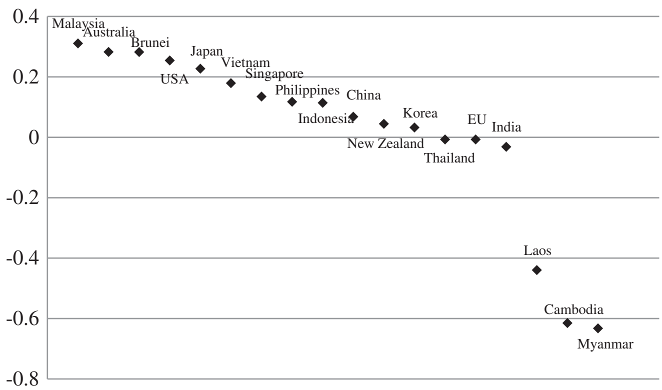


Fig. 1. Energy security improvement for eighteen countries (% Change from 1990 to 2010).

Table 4
Oil reserves for Southeast Asia.

Country	Total proven reserves (billion barrels).
Cambodia	0
Brunei	1.2
Indonesia	4.37
Laos	0
Malaysia	5.36
Myanmar	0.20
Philippines	0.14
Singapore	0
Thailand	0.46
Vietnam	0.6
Total	**12.33**

Table 5
Natural gas reserves for Southeast Asia.

Country	**Proven reserves (trillion cubic feet)**	**Possible reserves (trillion cubic feet)**	**Probable reserves (trillion cubic feet)**	**Total (trillion cubic feet)**
Cambodia	0	0	0	0
Brunei	8	4	0	12
Indonesia	90	42	34	166
Laos	0	0	0	0
Malaysia	58	28	0	86
Myanmar	21	17	10	48
Philippines	3	1	1	5
Singapore	0	0	0	0
Thailand	12	9	11	32
Vietnam	5	11	9	25
Total	**197**	**112**	**65**	**374**

largest oil reserves of any country in Southeast Asia and the second largest natural gas reserves after Indonesia [11]. Yet Malaysian planners emphasize the "sustainable" production of these reserves. Senior managers and directors at Petronas, the state owned oil company, focus on finding the "optimal" rate of development of reserves. Their strategy is to "move away from the Texan approach to producing oil," a method of making concessions agreements, exploiting resources, and leaving, with a "new model" of joint ventures that extract hydrocarbons "moderately" to ensure long-term availability of supply [12].

In terms of affordability and access, Malaysia's national electrification program has achieved one of the best rates in all of Southeast Asia, with more than 99 percent of the population boasting connections to the national grid in 2010, and a national policy in place to promote renewable energy since 2001. Then, planners created the Small Renewable Energy Power Program (SREP) to accomplish a 5 percent share of renewable electricity supply by 2005 [13]. Although it failed to meet this target [14], it did succeed in the construction of several waste-to-energy facilities and small hydroelectric power plants.

In terms of efficiency and innovation, the country's National Energy Policy of 1979 came after the oil shocks of the 1970s, when Malaysia was heavily dependent on imported oil. It stipulated three main objectives: (1) ensure an adequate and cost effective supply, in essence maximum use of domestic resources; (2) utilize energy efficiency and conservation and eliminate wasteful consumption; (3) protect the environment, or achieve the other two objectives without degrading Malaysia's rich ecological and social heritage. The Four Fuel Diversification Strategy of 1981 explicitly promoted hydroelectricity, natural gas, and coal as an alternative to oil, and contributed to dropping national oil dependence from 90 percent in 1980 to less than 10 percent in 2003. The Electricity Supply Act started the privatization of the electricity sector and enabled independent power producers to enter the wholesale electricity generation market. After a major blackout in 1993 followed by rolling brownouts in 1995, the government began planning its Fifth Fuel Diversification Policy of 2001 intended to promote other forms of renewable energy. These measures – especially privatization and the fuel diversification policies – have seen oil's share of national energy supply drop precipitously since the 1980s and the rise of coal and hydroelectricity in the nation's electricity mix.

Moreover, the SREP was intended not only to expand access, but as a way to promote innovation and technological learning in alternatives Malaysia had little experience with, such as waste incineration, small-scale hydro, and solar photovoltaic panels. One negative sign of the country's economic growth, however, has been rising levels of energy consumption. Malaysians, simply put, are using more per capita electricity due to urbanization, increasing income, and the emergence of a middle class with more affluent and consumerist tendencies. More Malaysians own detached housing, automobiles, and appliances such as electric fans (98.5 percent), color televisions (93 percent), washing machines (85.6 percent), refrigerators (77.4 percent), computers (28.9 percent) and air conditioners (14.4 percent) compared to only two decades ago [15].

Malaysia's performance on sustainability is more mixed. As a plus, the country strives to manage its forests and water well. Regulators passed a National Forest Act in the 1980s to classify forests and set limits on harvesting and deforestation. The rules mandated that only trees of a certain length and age could be felled (protecting both young and old trees), prohibited harvesting of timber and wood within an extensive network of reserves, set strict quotas, and relied on surveillance (now done by satellites) to track compliance. In 2007, the maximum harvest quota was 50,000 m^3, and newer standards require that those forests that have been harvested undergo regeneration and restoration efforts. Collectively, such policies have seen the amount of forest area, inclusive of plantations, grow from 58.7 percent of land area in 2000 to 63.6 percent of land area in 2005 [16].

However, Malaysia has struggled to lower its carbon footprint and emissions of sulfur dioxide. Every single ton of palm oil, one of the country's biggest exports, creates 6 t of palm fronds, 5 t of empty fruit bunches (EFB), 1 t of palm trunks, 1 t of mesocarp fiber, 750 kg of palm kernel cake and endocarp, and a staggering 100 t of palm oil mill effluent (POME). Before it is discharged, POME is usually collected in open ponds or storage takes to degrade, a practice that produces voluminous amounts of greenhouse gas emissions, as every ton creates 28 m^3 of methane. Taken together, such emissions from the palm oil industry account for roughly 12 percent of national greenhouse gas emissions [17]. Malaysia is also the second fastest growing emitter of greenhouse gases in the world with an annual rate per year of 7.9 percent, *excluding* changes in land use,

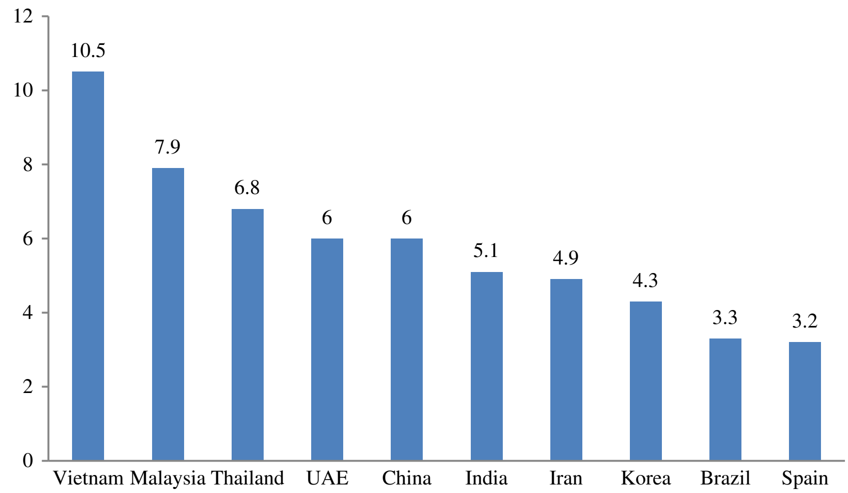


Fig. 2. Average annual growth rates in carbon dioxide emissions for the top 10 countries, 1990 to 2006 (%).

Table 6
Timeline of major energy policy events in Malaysia, 1949–2010.

Date	Event	Description
1949	Central electricity board formed	Central Electricity Board (CEB) created by the government for electricity generation, transmission, and distribution in Malaysia, renamed the National Electricity Board in 1965.
1974	Petroleum development act	The state-owned Petronas is given exclusive rights to own, explore, and produce petroleum and related products.
1975	National petroleum policy	Sets regulations for the oil and natural gas industries to ensure economic development needs are met.
1979	National energy policy	Sets the three objectives of supply, utilization, and the environment.
1980	National depletion policy	National petroleum policy is augmented to extend the life of domestic energy reserves and lower reserve to production ratios.
1981	Four-fuel diversification strategy	Strategy intends to develop non-oil based sources of energy such as natural gas, hydropower, and coal.
1990	Electricity supply act	Established the state-owned utility Tenaga Nasional Berhad to be peninsular Malaysia's national electricity provider, created by privatizing and corporatizing the NEB.
1999	Pusat Tenaga Malaysia formed	Pusat Tenaga Malaysia (PTM) created to promote energy efficiency and renewable energy.
1999	Five-fuel diversification strategy	Renewable sources of energy recognized as the fifth primary fuel in national energy supply.
2001	Small renewable energy power program launched	Small Renewable Energy Power (SREP) Program created to achieve 5 percent renewable electricity supply by 2005.
2002	Malaysian energy commission formed	Department of Electricity and Gas Supply at the Ministry of Energy transformed into a regulatory agency responsible for energy matters

numbers presented in Fig. 2. Put into future context, emissions in a business as usual scenario would grow 74 percent from 2005 to 2020 [18].

Lastly, in terms of regulation and governance, Table 6 shows major energy policy decisions in the past six decades [19]. Though the government has been criticized for corruption and nepotism in energy projects such as the Bakun Dam and the Sarawak Corridor of Renewable Energy in Borneo [20], it has steadily built up national capacity in the area of energy. It has a Ministry of Energy, Green Technology & Water responsible for energy planning, a Ministry of Natural Resources and Environment for environmental protection, and a Malaysian Energy Commission to oversee coordination. These actors, along with three state-linked utilities – Tenaga Nasional Berhad, Sarawak Energy Berhad, and Sabah Electricity Sendirian Berhad – have largely kept national energy policy consistent and coherent.

Myanmar

The situation in Myanmar (Burma), notwithstanding its rich cache of oil and natural gas, is noticeably different [21]. Less than 1 percent of the country's population reportedly use or have reliable access to electricity, and a majority of households (88 percent) depend on solid fuels such as wood and rice husks for cooking and heating [22]. Most rural villagers spend 233 h a year (about 20 h a month) collecting fuelwood, contributing to national deforestation and also inhibiting household productivity; more than two-thirds (70 percent) of households depend on diesel lamps, batteries, or candles for lighting. Indeed, the International Energy Agency has calculated that Myanmar has perhaps the poorest level of energy access in all of the Asia-Pacific, and percentages lower than a host of countries in Sub-Saharan Africa [23]. As Table 7 summarizes, it scored moderately well in only five areas: share of renewable energy, forest cover, carbon dioxide emissions from energy, sulfur dioxide emissions, and information.

Myanmar has strikingly low levels of energy availability. Though it has improved slightly since, in 1997 Myanmar had the lowest per capita primary energy supply in the world [24]. Myanmar remains a biomass-centered energy system, with wood alone meeting 62 percent of all primary energy consumption in 2008—more than five *times* the second most significant source, crude oil and petroleum products [25]. Myanmar has the stated energy policy goal of encouraging energy independence, improving hydroelectric sources of supply, expanding the grid to rural areas, and promoting energy efficiency and renewable energy [26], yet accomplishing these tasks is proving difficult. Blackouts

Table 7
Raw energy security data and adjusted energy security scores for Myanmar, 1990–2010.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio (years)	Self-sufficiency (%)	Share of renewable energy (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)
Raw Data									
1990	0.3	–	1.0	49	–	–	–	0.0	–
1995	0.3	–	0.9	41	–	–	–	0	0.1
2000	0.3	–	1.2	38	–	5	–	12	0.1
2005	0.3	29	1.5	45	186%	11	95	1	0.2
2010	0.3	32	1.5	62	120.9%	13	95	1	–
Scores									
1990	0.0	–	11.3	52.0	–	–	–	–	–
1995	0.0	–	11.8	42.5	–	–	–	–	0.0
2000	0.0	–	15.3	42.2	–	0.0	–	0.0	3.3
2005	4.2	11.5	17.6	45.8	0.0	0.0	0.0	22.1	6.1
2010	3.5	4.0	25.3	67.1	0.0	0.0	0.0	29.7	–

	Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related CO_2 (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance Rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP	Quality of energy information (completed data points)
Raw Data											
1990	1,791	26	9	60	57	0.1	0.001	–	–	–	10
1995	1,851	38	7	56	60	0.2	0.001	9	–	–	13
2000	1,751	31	4	53	66	0.2	0.003	6	–	–	14
2005	23,208	35	3	49	71	0.3	–	4	0.0	245	18
2010	16,884	29	4	48	71	0.2	–	2	0.0	255	17
Scores											
1990	32.8	0.0	1.8	79.0	39.4	49.9	100.0	–	–	–	42.9
1995	70.2	4.5	2.2	75.8	36.5	38.6	100.0	0.0	–	–	33.3
2000	85.0	0.0	1.2	72.5	37.0	93.8	88.0	0.0	–	–	40.0
2005	6.0	0.0	1.2	69.0	37.0	77.7		0.0	0.0	1.7	50.0
2010	12.6	0.0	2.0	67.6	32.6	0.3	–	0.0	0.0	1.4	0.0

and brownouts remain frequent in urban areas, and difficulty earning foreign exchange and lack of parts and labor has complicated attempts to repair and maintain existing power plants and the transmission network [27].

In terms of affordability and access, even though only a small fraction of Burmese citizens have access to electricity, the government's official goal is to expand electrification rates to 60 percent by 2015. Nonetheless the World Bank projected that Myanmar would need a staggering $444 million every year – almost 10 percent of its GDP, the highest of any country in Asia – to achieve universal access to electricity by 2030, making it unlikely [28].

Dependence on fuelwood and charcoal also exposes households to rising prices. The average price for firewood in Yangon, for example, increased by a factor of *eight* between 1988 and 1997, and it further *quadrupled* from 1998 to 2004. Analogously, the price of charcoal increased by a factor of *six* between 1998 and 1997 and increased further by *tripling* in price from 1998 to 2004. Government efforts to rapidly introduce alternatives such as briquettes and fuel sticks (made from paddy husk, sawdust, charcoal dust or petroleum coke with a suitable binding agent) have so far been insufficient to meaningfully reduce demand for fuelwood and charcoal [27]. And, in an understandable effort to reduce government deficits, the Burmese regime removed state subsidies on natural gas and diesel in 2007, leading to a doubling of domestic prices for bus fares and automobile fuel and spilling over into an increase in the price of basic commodities such as rice, beef, fish, milk, and eggs—hitting rural and poor households the hardest, and eventually leading to popular protest and a reactive state crackdown involving an "unknown" number of killings [29].

To encourage energy efficiency, the government launched an "Energy Thrift" campaign in 2002 following the establishment of a Supervisory Committee for Utilization of Power and Fuel [27]. But this pales in comparison to the government's efforts to rapidly increase energy supply—the formal national target is to grow the electricity grid at 8.5 percent per year, reaching 15,000 MW of capacity by 2020. Moreover, the country is one of few to see its energy intensity *worsen* for part of the past decade. Soe Myint, Director-General of the Myanmar Ministry of Energy, has explained that the true "overall objective" is to "increase the indigenous production of crude oil and natural gas to fulfill domestic demand and to export the excess to gain hard currency," rather than to invest in energy efficiency or domestic innovation [30]. Indeed, all indications point to a strong national strategy towards exports of oil, gas, and electricity rather than domestic use [31]. In 1990, for example, oil and gas exports were negligible, and they amounted to less than $1 million in 1998. However, this figure grew to $800 million in 2002 and $1.4 billion in 2005, when natural gas accounted for 87 percent of Myanmar's trade surplus [32]. At present, more than two dozen firms from Australia, Canada, China, France, India, Indonesia, Japan, Malaysia, Singapore, Thailand, the United Kingdom, and United States are involved in oil and gas extraction within Myanmar. In the electricity sector, national planners are embarking upon a Myanmar–Thai "cooperative project" to dam the Thanlwin (Salween) river along the border to construct a series of hydroelectric dams to export power to Thailand. The first of these is supposed to generate more than 7000 MW, and is currently at the stage of surveying and soliciting finance [27].

In the realm of sustainability, Myanmar has performed modestly due in part to its low levels of access—reflecting, in turn, smaller pollution footprints. In terms of its greenhouse gas emissions associated with energy production and use, these are dwarfed by those from the agricultural and forestry sectors, excluded from our index, but still amount to 7.8 million metric tons of carbon dioxide equivalent, when traditional biomass fuel combustion is excluded [33]. When changes in land use and deforestation are included, however, Myanmar ranks *third* in the world, coming only after Indonesia and Brazil. In 2000, its emissions within this sector amounted to 190 million metric tons of CO_2e [34]. Myanmar is one of the highest countries in the world for the percentage of overall greenhouse gas emissions coming from the land use and agricultural sector, at 83.7 percent. Despite its relatively undeveloped economy, as of 2000, Table 8 shows that Myanmar was sixteenth in the world for overall carbon equivalent emissions.

In addition, energy use is intimately linked to deforestation. High rates of rural poverty place severe stress on Burmese forests and mangroves for fuelwood collection and charcoal production—homes cannot afford modern energy services, so they cut down trees or scavenge for free wood. As an independent United Nations assessment summated:

> *The demand for fuelwood and charcoal for cooking is rising with the growth in population, resulting in indiscriminate cutting of trees for fuelwood in forest areas adjacent to villages and towns. In addition, illegal logging of valuable trees in some areas is worsening deforestation and environmental degradation…It is highly probable that unless alternative sources of fuel are provided the rate of depletion of unclassified forests will be aggravated, particularly in the dry zone. The rural poor, having no other alternative sources of energy for cooking, rely only on fuelwood collected from adjacent degraded forests and are extending their collecting into other unclassified forests…The extensive mangroves in the Ayeyarwaddy delta are much degraded because of exploitation for fuelwood and charcoal production.* [35]

Fuelwood collection does not necessitate chopping down an entire tree, but it does prune branches and deplete forests of needed nutrients; charcoal production almost always necessitates cutting a tree to stump level. Myanmar does formally practice "sustainable forest management," but these practices simply do not produce enough wood. Estimates predicated on standing stocks of forests give an annual sustainable yield of about 13 to 15 million cubic tons per year, yet demand for wood far exceeds 20 million cubic tons per year—a shortfall of 5 million cubic tons,

Table 8
Carbon equivalent emissions by country for 2000 (Million metric tons of carbon).

Country	Emissions from non-LULUFC sources		Emissions from LULUCF sources	Total GHG emissions	
	MtC	Rank	MtC	MtC	Rank
United States	1891	1	−110	1781	1
China	1348	2	−13	1335	2
European Union-25	1290	3	−6	1284	3
Indonesia	137	15	700	837	4
Brazil	232	8	375	607	5
Russia	523	4	15	538	6
India	514	5	−11	503	7
Japan	359	6	1	361	8
Germany	276	7	0	276	9
Malaysia	45	33	191	236	10
Canada	186	9	18	203	11
United Kingdom	178	10	0	178	12
Mexico	140	14	26	166	13
Italy	145	11	−1	144	14
South Korea	142	12	0	143	15
Myanmar	23	48	116	139	16
France	140	13	−2	138	17
Australia	134	16	1	135	18
Iran	131	18	2	133	19
Ukraine	132	17	0	132	20

or approximately 275,000 acres (111,288 ha) of natural forest destroyed each year [27].

Lastly, in terms of regulation and governance, more than a dozen government agencies are involved in energy and electricity planning, and even greater numbers of actors in the private sector and civil society complicate the energy policy landscape. As of 2010, numerous government entities operated in the sphere of energy and electricity: the Ministry of Energy (MOE), Energy Planning Department, Myanma Oil and Gas Enterprise, Myanma Petrochemical Enterprise, Myanma Petroleum Products Enterprise, Ministry of Electric Power No. 1, Ministry of Electric Power No. 2, Myanma Electric Power Enterprise, Yangon City Electricity Supply Board, Ministry of Mines, Ministry of Forestry, Ministry of Science and Technology, Ministry of Education, and the Ministry of Cooperatives [36]. The policy environment is further complicated by a large number of energy access programs in recent years. Taking just one technology, fuel-efficient stoves, sixteen different projects have been implemented from 1997 to 2011 involving a variety of different actors [37]. These actors have included EcoDev, United Nations Development Programme, Groupe de Recherche et de Travail, Forest Resource Environmental Development Association, Ever Green Group, Metta Foundation, Mangrove Service Network, and Malteser.

This somewhat convoluted policy environment creates overlapping and at times confusing mandates and poorly coordinated efforts at promoting energy access. For example, if a microhydro plant wanted to power a mini-grid (at the village scale) but also export excess electricity to the national grid, it would require the involvement of the Ministry of Electric Power 1 (responsible for planning permits and maintenance for hydroelectricity), the Ministry of Electric Power 2 (responsible for transmission and distribution), and the Yangon City Electricity Supply Board (responsible for electricity sales). Similarly, a hybrid solar-biomass facility would need the involvement of the Ministry of Forestry (responsible for biomass and fuelwood), Ministry of Education (responsible for basic and applied research), and the Ministry of Science and Technology (responsible for development of renewable power sources) [38].

Lastly, Myanmar's long rule under a military junta from 1962 to 2011 created a reputation for authoritarianism, earning it the nickname "the bamboo curtain" [39]. Many foreign investors perceive Myanmar as having an "isolationist" and "non-liberal" economy, which complicates efforts at attracting private financing for infrastructure projects [40]. The 2012 Index of Economic Freedom ranked Myanmar among the ten most "repressive" economies in the world out of 180 [41]. Transparency International's 2011 "Corruption Perceptions Index" ranked them 180th out of 183 countries [42]. One study went so far as to call the country a "gigantic, often grotesque bureaucracy" [43]. The government has reputedly viewed communities and rural villages not as partners in energy development, but obstacles to it. In the extreme, some have accused the Burmese regime of committing human rights violations such as forced labor, murder, interrupted livelihoods, and the covert transfer of weapons in their construction of energy projects such as the Yedana Gas Pipeline, Yetagun Pipeline, and Shwe Gas Project [44].

Conclusion

This article has created and applied an energy security index, utilizing twenty indicators that encompass economic, social, political, and environmental aspects of energy security, and analyzed the status of energy conditions in eighteen countries from 1990 to 2010. Even though Malaysia and Myanmar are both endowed with substantial energy resources, one has managed to improve its energy security greater than even fully industrialized countries such as the United States and European Union; the other has seen its energy security erode on virtually all fronts. Readers can draw at least three conclusions from this exercise.

First, according to the index, Malaysia was the country that most improved its energy security. To do so, it relied on "strategic" management of its oil and gas reserves to balance depletion rates with future use, and it phased oil out of the electricity sector after the oil shocks of the 1970s and 1980s. It sponsored a massive, state-led electrification program along with a Small Renewable Energy Power Program to expand access to energy services and further diversify the energy mix. It attempted to invest in domestic research on palm oil and landfill gas waste-to-energy facilities and small-scale hydroelectric dams, has maintained comparatively healthy forestry and water sectors, and coordinated energy policy through a select number of national institutions.

Second, according to the index, Myanmar was the country that saw its energy security most deteriorate. It focused little on expanding energy access and instead directed efforts at energy exports to acquire foreign exchange. It, counter to the stated trend of most carbon conscious countries, has been supplying *less* electricity from renewable resources over time. Energy prices for virtually all fuels and services – from charcoal and fuelwood to electricity and diesel – have risen starkly in the past few years, and levels of access remain the lowest in all of Asia. The country has seen its energy intensity rise – indicating a transition to a less energy-efficient economy – and conducts virtually no research on advanced energy technology or practices. It is a potent emitter of greenhouse gases when land use change and forestry are included, and the regime has been accused of grave human rights violations in pursuit of increased oil and gas production.

Third, and most troublingly, is that the index reveals tradeoffs within different components of energy security. Malaysia achieved its diversification and almost universal energy access only with large subsidies and one of the fastest growth rates in greenhouse gas emissions. Myanmar's extreme export oriented energy strategy leaves its population literally in the dark, and ironically its inability to effectively plan, its poor capacity and low levels of access, enable it to score favorably on environmental indicators (when land use change is excluded). The problem is that it appears that some elements of energy security, such as availability and affordability, can come only at the expense of others, such as sustainability and efficiency. This ability for components to conflict with each other may explain why most countries continue to struggle in their attempts to improve any holistic sense of energy security.

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Appendix A. Raw energy security data

See appendix Tables A1–A5.

Appendix B. Energy security performance scores

See appendix Tables B1–B5.

Table A1
Energy security data for 18 countries for 1990.
Source: Sovacool et al., 2011. Data for average reserve to production ratios, stability of electricity prices, research intensity, worldwide governance rating, and energy exports not available. The dash "-" also indicates data for a particular metric was not available. In some cases 1990 data was not available and data from the closest year (e.g., 1989 or 1991) was used.

	Total primary energy supply per capita (ktoe)	Self sufficiency (%)	Share of renewable energy in total primary energy supply (%)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related carbon dioxide emissions (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Per capita energy subsidies (2009 U.S. Dollars PPP)	Quality of energy information (out of 14 total)
Brunei	6.9	8.9	0	–	–	0.0	12,976	5	510	59	–	13.1	0.011	–	9
Cambodia	–	–	41	–	–	0.0	623	–	0	73	35	0.1	0.002	–	7
Indonesia	1.7		18	37	–	0.0	6,280	14	35	64	71	0.8	0.004	45	12
Laos	–	–	95	–	–	0.0	1,911	-	0	75	29	0.1	0.003	–	7
Malaysia	1.2	2.2	16	–	–	150.7	7,920	7	30	68	88	2.7	0.021	–	11
Myanmar	0.3	1.0	49	–	–	0.0	1,791	26	9	60	57	0.1	0.001	–	10
Philippines	0.4	0.6	46	55	–	0.0	4,919	15	0	35	84	0.6	0.010	–	11
Singapore	3.8	0.0	0	–	0	92.5	11,262	3	0	3	100	9.5	0.110	–	12
Thailand	0.7	0.6	11	93	66	120.1	5,577	11	2	31	91	1.4	0.014	–	13
Vietnam	0.4	1.0	63	–	–	0.0	4,430	25	-	29	58	0.3	0.002	–	9
China	0.8	1.0	21	–	85	0.0	21,261	7	29	17	67	2.0	0.022	11	12
India	0.4	0.9	26	–	78	517.7	7,696	20	18	22	72	0.7	0.006	13	13
Japan	3.6	0.2	12	100	0	0.0	5,794	5	0	68	100	8.6	0.017	–	12
Korea	1.6	0.2	5	100	2	135.9	8,564	9	0	65	93	5.4	0.057	104	14
USA	7.7	0.9	12	100	0	0.0	10,540	9	4	33	99	19.5	0.090	281	13
EU	3.2	0.6	12	100	0	0.0	7,268.09	0	4	34	100	7.9	0.130	-	12
Australia	5.0	1.8	10	100	0	0.0	8,861	7	6	22	100	15.2	0.088	–	12
New Zealand	3.6	0.9	80	100	0	0.0	11,090	11	4	29	100	6.3	0.022	–	12

Table A2
Energy security data for 18 countries for 1995.
Source: Sovacool et al., 2011. Data for average reserve to production ratios and energy exports not available. The dash "-" also indicates data for a particular metric was not available. In some cases 1995 data was not available and data from the closest year (e.g., 1994 or 1996) was used.

	Total primary energy supply per capita (ktoe)	Self sufficiency (%)	Share of renewable energy in total primary energy supply (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)	Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related carbon dioxide emissions (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance Rating	Per capita energy subsidies (2009 U.S. Dollars PPP)	Quality of energy information (out of 17)
Brunei	7.8	7.9	0	–	–	–	0	–	9,791	4	340	57	–	15.9	0.031	71	–	11
Cambodia	0.3	0.9	26	–	–	–	0	–	1,348	40	0	69	37	0.1	0.002	19	–	12
Indonesia	0.7	1.6	18		63		675		6,061	12	20	59	74	1.0	0.004	38	3	14
Laos	–	–	97	43	15	98	0	–	1,801	–	0	73	44	0.1	0.003	28	–	12
Malaysia	1.8	1.7	14	9	–	–	121	0.4	7,617	9	30	67	92	3.8	0.021	66	–	14
Myanmar	0.3	0.9	41	–	–	–	0	0.1	1,851	38	7	56	60	0.2	0.001	9	–	13
Philippines	0.5	0.5	38	38	–	–	143		5,825	17	2	31	87	0.8	0.009	52	–	13
Singapore	5.3	0.0	0	3	–	0	95	1.4	10,886	4	0	3	100	10.8	0.118	84	–	15
Thailand	1.0	0.5	9	13	–	72	85	0.1	6,222	8	1	30	94	2.4	0.021	58	–	15
Vietnam	0.4	1.2	73	–	–	87	326	–	5,385	22	15	32	68	0.4	0.003	37	–	13
China	0.9	1.0	20	–	–	80	102	0.6	15,349	7	20	18	74	2.5	0.028	42	4	15
India	0.4	0.9	18	–	–	97	312	0.6	8,723	19	10	22	76	0.8	0.007	44	2	15
Japan	4.0	0.2	10	−2	100	0	63	2.8	6,077	5	0	68	100	9.1	0.017	78	–	16
Korea	1.0	0.1	2	35	100	0	125	2.4	9,735	14	0	64	90	8.0	0.073	65	–	16
USA	7.8	0.8	12	3	100	0	46	2.5	10,030	7	3	33	99	19.3	0.068	91	46	17
EU	3.2	0.7	13	47	100	0	0	–	6,505.76	0	3	35	100	7.6	0.086	79	–	15
Australia	5.1	2.0	10	8	100	0	0	1.6	8,447	7	5	22	100	15.7	0.088	90	–	16
New Zealand	4.0	0.8	84	13	100	0	75	1.1	10,658	11	3	30	100	6.7	0.023	98	–	16

Table A3
Energy security data for 18 countries for 2000.
Source: Sovacool et al., 2011. Data for average reserve to production ratios and energy exports not available. The dash "-" also indicates data for a particular metric was not available. In some cases 2000 data was not available and data from the closest year (e.g., 1999 or 2001) was used.

	Total primary energy supply per capita (ktoe)	Self sufficiency (%)	Share of renewable energy in total primary energy supply (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)	Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related carbon dioxide emissions (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance Rating	Per capita energy subsidies (2009 U.S. Dollars PPP)	Quality of energy information (out of 17)
Brunei	7.4	8.0	0	–	99	–	87	0.0	9,607	1	307	55	99	14.0	0.026	68	–	14
Cambodia	0.3	0.8	10	–	16	96	293	0.0	1,526	19	0	65	46	0.2	0.002	26	–	15
Indonesia	0.8	1.6	17	–	53	72	148	0.1	6,997	11	13	54	77	1.3	0.006	26	76	16
Laos	–	–	90	1002%	–	95	315	0.0	3,756	–	0	72	48	0.2	0.010	19	–	12
Malaysia	2.0	1.6	19	−4%	97	–	83	0.9	8,108	8	23	66	97	4.8	0.018	61	–	15
Myanmar	0.3	1.2	38	–	5	–	12	0.1	1,751	31	4	53	66	0.2	0.003	6	–	14
Philippines	0.5	0.5	44	37%	87	49	152	0.2	6,248	14	2	27	88	0.9	0.008	42	–	16
Singapore	4.5	0.0	0	49%	100	0	130	1.9	10,285	4	0	3	100	10.6	0.271	87	–	16
Thailand	1.2	0.6	8	45%	82	33	141	0.3	7,421	8	1	29	96	2.6	0.021	61	–	16
Vietnam	0.5	1.3	56	–	76	–	273	0.2	5,936	14	9	38	79	0.6	0.003	33	–	14
China	0.9	1.0	17	22%	99	59	141	0.9	10,619	7	14	19	80	2.4	0.027	38	–	16
India	0.5	0.8	14	–	43	82	299	0.8	7,729	28	6	23	81	1.0	0.008	47	–	15
Japan	4.1	0.2	11	−2%	100	0	67	3.0	6,180	4	0	68	100	9.3	0.020	83	–	16
Korea	0.9	0.2	2	83%	100	0	168	2.4	9,684	16	0	64	93	9.0	0.091	67	205	17
USA	8.0	0.7	10	18%	100	0	58	2.7	8,820	6	3	33	99	20.2	0.063	92	247	17
EU	3.3	0.7	14	51%	100	0	248	1.6	5,957.81	0	4	36	100	7.6	0.074	82	124	17
Australia	5.6	2.2	9	20%	100	0	121	1.6	8,246	7	9	21	100	17.6	0.136	94	–	16
New Zealand	4.3	0.9	73	18%	100	0	89	1.1	9,663	11	3	31	100	7.7	0.025	95	–	16

Table A4
Energy security data for 18 countries for 2005.
Source: Sovacool et al., 2011. The dash "-" indicates data for a particular metric was not available. In some cases 2005 data was not available and data from the closest year (e.g., 2004 or 2006) was used.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio for the four primary energy fuels (uranium, coal, natural gas, and oil) (years)	Self sufficiency (%)	Share of renewable energy in total primary energy supply (%)	Stability of electricity prices (% change) (%)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)	Energy intensity (Btu per year 2005 U.S. Dollars PPP)
Brunei	6.8	46	8.3	0	−2	99	10	68	0.0	12,121
Cambodia	0.3	0	0.7	5	17	20	92	328	–	8,790
Indonesia	0.8	67	1.6	14	81	54	72	128	0.0	16,480
Laos	0.0	0	0.3	91	160	44	95	171	–	12,730
Malaysia	2.4	44	1.5	12	−9	98	5	97	0.6	16,596
Myanmar	0.3	29	1.5	45	186	11	95	1	0.2	23,208
Philippines	0.5	156	0.6	33	69	81	47	176	0.1	13,292
Singapore	5.6	0	0.0	0	6	100	0	142	2.3	16,216
Thailand	1.5	84	0.6	7	20	99	34	167	0.2	20,794
Vietnam	0.6	49	1.4	41	38	84	67	275	–	22,651
China	1.3	94	1.0	17	30	99	49	145	1.3	30,236
India	0.5	177	0.8	16	32	56	-	350	0.8	19,468
Japan	4.1	9	0.2	10	3	100	0	92	3.3	5,032
Korea	0.9	48	0.2	1	19	100	0	193	3.0	10,924
USA	7.8	248	0.7	9	42	100	0	61	2.6	7,960
EU	3.4	87	0.6	14	33	100	0	294	1.6	5,726
Australia	5.8	236	2.3	8	27	100	0	100	1.9	7,360
New Zealand	3.9	122	0.8	65	27	100	0	72	1.2	7,862

	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related carbon dioxide emissions (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP	Quality of energy information (out of 19)
Brunei	4	264	53	–	13.6	–	64	0.0	560	17
Cambodia	23	0	59	56	0.3	–	21	0.0	68	17
Indonesia	12	10	49	80	1.5	0.005	30	99.9	77	19
Laos	21	0	70	54	0.2	–	15	0.0	82	17
Malaysia	1	16	64	100	6.0	–	64	35.8	172	18
Myanmar	35	3	49	71	0.3	–	4	0.0	245	18
Philippines	12	1	24	90	0.8	–	42	0.5	7	18
Singapore	5	0	3	100	10.5	–	88	0.9	0	18
Thailand	8	2	28	98	3.3	–	54	3.6	66	18
Vietnam	11	7	42	88	1.0	–	36	46.1	15	17
China	7	7	21	86	3.9	0.026	35	27.9	22	19
India	26	6	23	85	1.1	0.006	48	0.3	19	18
Japan	5	0	68	100	9.6	0.007	85	0.2	43	19
Korea	16	0	65	96	9.7	–	74	0.0	175	18
USA	6	3	33	99	19.5	0.046	85	9.6	270	19
EU	0	3	37	100	7.6	–	82	0.0	150	18
Australia	6	4	21	100	19.0	0.005	92	33.2	544	19
New Zealand	7	1	31	100	8.0	0.021	96	1.0	272	19

Table A5
Energy security data for 18 countries for 2010.
Source: Sovacool et al., 2011. The dash “-” indicates data for a particular metric was not available. In some cases 2010 data was not available and most recent data was from 2007, 2008, and/or 2009.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio for the four primary energy fuels (uranium, coal, natural gas, and oil) (years)	Self sufficiency (%)	Share of renewable energy in total primary energy supply (%)	Stability of electricity prices (% change)(%)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)	Energy intensity (Btu per year 2005 U.S. Dollars PPP)
Brunei	9.1	52	5.8	0	−0.1	100	5	61	–	18,968
Cambodia	0.4	0	0.7	4	3.4	24	91	290	–	8,055
Indonesia	0.9	66	1.8	14	29.3	65	58	114	–	17,125
Laos	0.0	806	0.3	92	33.3	55	95	292	–	11,815
Malaysia	2.7	50	1.3	9	8.0	99	0	102	0.6	15,064
Myanmar	0.3	32	1.5	62	120.9	13	95	1	–	16,884
Philippines	0.5	130	0.6	34	30.8	90	47	188	–	11,185
Singapore	3.8	0	0.0	0	13.7	100	0	180	2.6	15,784
Thailand	1.6	81	0.6	8	−12.6	99	25	246	0.2	19,855
Vietnam	0.7	32	1.2	37	79.4	98	61	242	–	24,332
China	1.6	79	0.9	17	–	99	48	190	1.5	26,718
India	0.5	161	0.8	15	5.4	66	60	296	0.8	18,825
Japan	3.7	5	0.2	10	7.2	100	0	120	3.4	4,741
Korea	4.7	45	0.2	1	25.4	100	0	217	3.5	10,349
USA	7.1	237	0.8	11	19.4	100	0	76	2.7	7,280
EU	3.2	128	0.6	17	29.4	100	0	197	1.5	5,360
Australia	6.1	217	2.4	8	25.0	100	0	83	2.2	7,106
New Zealand	4.2	127	0.9	73	31.0	100	0	117	1.3	7,540

	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related carbon dioxide emissions (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance Rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP	Quality of energy information (out of 19)
Brunei	5	188	52	99	18.9	–	72	0.0	861	17
Cambodia	12	0	57	61	0.3	–	23	0.0	68	17
Indonesia	11	9	47	80	1.7	–	37	41.9	109	17
Laos	13	0	69	57	0.2	–	18	0.0	80	17
Malaysia	2	20	63	100	6.7	–	57	28.0	509	18
Myanmar	29	4	48	71	0.2	–	2	0.0	255	17
Philippines	13	1	23	91	0.8	–	37	0.6	5	17
Singapore	5	0	3	100	9.2	–	86	0.4	0	18
Thailand	6	1	28	98	3.4	–	46	1.5	50	18
Vietnam	11	6	43	94	1.2	–	36	32.2	16	17
China	6	5	22	89	4.9	–	37	9.0	42	17
India	25	5	23	88	1.3	–	46	0.4	41	18
Japan	5	0	68	100	9.0	0.006	85	0.2	47	19
Korea	16	0	64	98	10.3	–	72	0.0	194	18
USA	6	3	33	99	18.4	0.033	84	11.1	287	19
EU	0.06	2	37	100	7.4	–	82	0.0	142	18
Australia	7	4	21	100	18.5	0.123	93	37.1	567	19
New Zealand	7	1	31	100	7.7	0.019	96	1.1	306	19

Table B1
Energy security performances for 18 countries for 1990.

	Total primary energy supply per capita	Self sufficiency	Share of renewable energy in total primary energy supply	% Population with high quality connections to the electricity grid	Households independent from traditional fuels	Retail price of gasoline/ petrol	Energy intensity	Grid efficiency	Energy resources and stockpiles	Forest cover	Water availability	Per capita energy-related carbon dioxide emissions	Sulfur dioxide emissions	Per capita energy subsidies	Quality of Energy Information
Brunei	89.2	100.0	0.0	–	–	–	1.9	83.1	100.0	78.2	–	0.1	12.2	–	28.6
Cambodia			42.6	–	–	–	100.0		0.0	97.7	8.5	100.0	79.6	–	0.0
Indonesia	4.3	18.7	18.9	0.0	–	–	7.2	48.2	6.8	85.1	59.2	6.1	35.2	4.3	71.4
Laos	–	–	100.0	–	–	–	30.5	–	0.0	100.0	0.0	94.3	49.6	–	0.0
Malaysia	12.8	25.0	17.3	–	–	53.0	5.1	73.4	6.0	90.3	83.1	1.6	5.8	–	57.1
Myanmar	0.0	11.3	52.0	9	–	–	32.8	0.0	1.8	79.0	39.4	49.9	100.0	–	42.9
Philippines	2.4	6.4	48.2	27.6	–	–	10.0	45.3	0.0	44.7	77.5	7.7	13.9	–	57.1
Singapore	47.3	0.0	0.0	–	100.0	100.0	2.7	87.5	0.0	0.0	100.0	0.3	0.2	–	71.4
Thailand	6.4	7.1	11.9	88.4	22.8	72.0	8.5	60.2	0.3	38.9	87.3	3.3	9.2	–	85.7
Vietnam	1.4	11.5	66.2	–	–	–	11.5	3.9	–	35.4	40.8	19.0	56.6	–	28.6
China	6.7	11.6	22.3	–	0.0	–	0.0	74.1	5.6	18.7	53.5	2.3	5.3	100	71.4
India	1.5	10.4	27.1	–	8.4	0.0	5.3	26.2	3.5	25.2	60.6	6.9	22.2	84.2	85.7
Japan	44.5	1.9	12.9	100.0	100.0	–	8.1	81.8	0.0	90.8	100.0	0.3	7.3	–	71.4
Korea	18.7	2.7	5.0	100.0	97.4	61.1	4.5	64.8	0.0	85.3	90.1	0.7	1.4	7.0	100.0
USA	100.0	9.7	12.5	100.0	100.0	–	3.1	65.1	0.8	40.8	98.6	0.0	0.5	0	85.7
EU	40.1	7.3	12.5	100.0	100.0	–	5.8	100.0	0.7	42.6	100.0	0.4	0.0	–	71.4
Australia	64.4	20.6	10.5	100.0	100.0	–	4.2	73.8	1.2	25.7	100.0	0.1	0.5	–	71.4
New Zealand	45.7	10.1	84.4	100.0	100.0	–	2.8	57.3	0.7	35.5	100.0	0.5	5.2	–	71.4

Note: data for average reserve to production ratios, stability of electricity prices, research intensity, worldwide governance rating, and energy exports not available. The dash "-" also indicates data for a particular metric was not available.

Table B2
Energy security performance scores for 18 countries for 1995.

	Total primary energy supply per capita	Self sufficiency	Share of renewable energy in total primary energy supply	Stability of electricity prices	% Population with high quality connections to the electricity grid	Households independent from traditional fuels	Retail price of gasoline/petrol	Research intensity	Energy intensity	Grid efficiency	Energy resources and stockpiles	Forest cover	Water availability	Per capita energy-related carbon dioxide emissions	Sulfur dioxide emissions	Worldwide governance Rating	Per capita energy subsidies	Quality of Energy Information
Brunei	100.0	100.0	0.0	–	–	–	–	–	5.5	91.4	100.0	76.7	–	0.1	3.1	69.8	–	0.0
Cambodia	0.3	10.9	26.4	–	–	–	–	–	100.0	0.0	0.0	94.3	0.0	51.5	78.6	11.2	–	16.7
Indonesia	5.6	20.5	18.5	–	56.2	–	0.0	–	14.8	70.9	5.8	79.8	58.7	5.9	30.9	32.3	62.7	50.0
Laos	–	–	100.0	0.7	0.0	0.0	–	–	72.4	–	0.0	100.0	11.1	100.0	47.4	20.6	–	16.7
Malaysia	20.2	22.1	14.7	30.3	–	–	33.3	11.1	9.8	78.6	8.7	90.8	87.3	1.3	5.0	64.5	–	50.0
Myanmar	0.0	11.8	42.5	–	–	–	–	0.0	70.2	4.5	2.2	75.8	36.5	38.6	100.0	0.0	–	33.3
Philippines	2.9	6.0	38.7	1.7	–	–	27.2	–	15.7	57.3	0.6	39.5	79.4	7.1	13.7	47.8	–	33.3
Singapore	67.1	0.0	0.0	93.1	–	100.0	44.6	48.1	3.9	90.6	0.0	0.0	100.0	0.3	0.0	84.3	–	66.7
Thailand	10.1	6.7	9.4	18.8	–	26.3	50.8	0.0	14.1	79.8	0.3	38.2	90.5	2.3	5.1	54.8	–	66.7
Vietnam	1.8	14.6	75.4	–	–	10.9	7.8	–	17.8	45.7	4.3	41.4	49.2	16.0	48.1	31.4	–	33.3
China	7.9	12.9	20.2	–	–	18.1	40.9	18.5	0.0	81.6	5.7	20.7	58.7	2.2	3.5	37.1	52.9	66.7
India	1.9	11.0	18.8	–	–	0.5	8.5	18.5	7.3	52.5	3.0	26.7	61.9	7.1	17.2	38.8	100	66.7
Japan	48.6	2.5	10.6	100.0	100.0	100.0	71.0	100.0	14.7	88.3	0.0	92.9	100.0	0.4	6.4	77.9	–	83.3
Korea	9.8	1.9	1.6	2.5	100.0	100.0	32.1	85.2	5.6	65.3	0.0	86.9	84.1	0.5	0.7	63.5	–	83.3
USA	98.9	10.2	11.9	100.0	100.0	100.0	100.0	88.9	5.1	82.6	1.0	42.0	98.4	0.0	0.8	92.1	0	100.0
EU	39.3	8.7	13.4	0.0	100.0	100.0	–	–	13.1	100.0	1.0	45.7	100.0	0.5	0.4	79.0	–	66.7
Australia	63.6	25.6	10.3	32.5	100.0	100.0	–	55.6	7.9	83.5	1.6	26.1	100.0	0.1	0.4	91.3	–	83.3
New Zealand	48.8	10.7	86.0	18.5	100.0	100.0	58.0	37.0	4.2	71.8	0.9	37.7	100.0	0.6	4.4	100.0	–	83.3

Note: data for average reserve to production ratios and energy exports not available. The dash "-" also indicates data for a particular metric was not available.

Table B3
Energy security performance scores for 18 countries for 2000.

	Total primary energy supply per capita	Self sufficiency	Share of renewable energy in total primary energy supply	Stability of electricity prices	% Population with high quality connections to the electricity grid	Households independent from traditional fuels	Retail price of gasoline/ petrol	Research intensity	Energy intensity	Grid efficiency	Energy resources and stockpiles	Forest cover	Water availability	Per capita energy-related carbon dioxide emissions	Sulfur dioxide emissions	Worldwide governance Rating	Per capita energy subsidies	Quality of Energy Information
Brunei	91.2	100.0	0.0	–	99.2	–	64.4	0.0	1.8	96.6	100.0	75.1	98.1	0.4	8.2	69.9	–	40.0
Cambodia	0.5	10.1	10.8	–	11.4	0.0	13.6	0.0	100.0	39.9	0.0	90.8	0.0	88.9	100.0	22.0	–	60.0
Indonesia	6.2	19.3	18.4	–	50.9	25.1	34.6	3.3	8.7	65.5	4.3	74.2	57.4	12.3	37.1	22.6	100	80.0
Laos	–	–	100.0	0.0	–	1.2	12.0	0.0	30.7	–	0.0	100.0	3.7	100.0	23.7	14.5	–	0.0
Malaysia	22.6	20.1	21.3	100.0	96.7	–	67.9	30.0	5.2	75.2	7.5	91.3	94.4	2.7	12.4	61.5	–	60.0
Myanmar	0.0	15.3	42.2	–	0.0	–	0.0	3.3	85.0	0.0	1.2	72.5	37.0	93.8	88.0	0.0	–	40.0
Philippines	3.3	6.1	48.2	46.9	86.7	49.5	33.4	6.7	11.7	55.4	0.7	34.1	77.8	18.1	27.4	41.0	–	80.0
Singapore	54.2	0.0	0.0	35.2	100.0	100.0	40.7	63.3	0.5	88.6	0.0	0.0	100.0	0.8	0.0	91.4	–	80.0
Thailand	11.4	7.6	9.1	38.7	81.2	65.6	36.9	10.0	7.2	74.9	0.4	37.5	92.6	5.8	10.5	61.8	–	80.0
Vietnam	2.6	16.2	62.0	–	74.5	–	15.1	6.7	13.2	56.1	3.0	50.2	61.1	29.1	73.2	30.6	–	40.0
China	7.6	12.1	19.3	78.5	98.5	38.5	36.8	30.0	0.0	78.1	4.5	22.8	63.0	6.2	8.0	35.7	–	80.0
India	2.3	10.0	16.0	–	40.0	14.8	13.1	26.7	6.3	11.9	2.0	28.3	64.8	16.7	29.5	46.2	–	60.0
Japan	49.1	2.5	11.7	100.0	100.0	100.0	86.7	100.0	12.1	85.9	0.0	95.0	100.0	1.0	10.8	86.5	–	80.0
Korea	7.6	2.2	1.9	19.9	100.0	100.0	29.6	80.0	1.6	49.6	0.0	88.5	87.0	1.1	1.7	68.4	9.0	100.0
USA	100.0	9.1	10.5	96.1	100.0	100.0	100.0	90.0	3.4	82.0	1.0	43.3	98.1	0.0	2.9	96.8	0	100.0
EU	39.5	8.4	15.3	33.8	100.0	100.0	19.4	52.7	13.1	100.0	1.2	48.1	100.0	1.4	2.3	85.7	44.0	100.0
Australia	68.6	26.9	9.7	90.1	100.0	100.0	44.1	53.3	4.8	76.8	3.0	26.4	100.0	0.1	0.9	99.1	–	80.0
New Zealand	51.8	10.6	80.2	100.0	100.0	100.0	62.8	36.7	1.7	65.9	0.9	40.0	100.0	1.4	8.5	100.0	–	80.0

Note: data for average reserve to production ratios and energy exports not available. The dash "-" also indicates data for a particular metric was not available.

Table B4
Energy security performance scores for 18 countries for 2005.

	Total primary energy supply per capita	Average reserve to production ratio for the four primary energy fuels (uranium, coal, natural gas, and oil)	Self sufficiency	Share of renewable energy in total primary energy supply	Stability of electricity prices	% Population with high quality connections to the electricity grid	Households independent from traditional fuels	Retail price of gasoline/petrol	Research intensity	Energy intensity
Brunei	86.7	18.7	100.0	0.0	100.0	99.1	89.5	88.8	0.0	29.8
Cambodia	4.3	0.0	8.8	5.8	15.6	9.9	2.7	1.4		48.7
Indonesia	10.4	26.9	18.9	15.5	2.0	48.1	24.0	37.0	0.0	16.7
Laos	0.0	0.0	3.6	100.0	0.3	36.9	0.0	22.3		27.5
Malaysia	30.9	17.7	17.7	13.6	100.0	97.5	94.7	55.8	18.2	16.4
Myanmar	4.2	11.5	17.6	45.8	0.0	0.0	0.0	22.1	6.1	6.0
Philippines	5.9	62.7	6.6	36.2	2.6	78.0	50.5	21.0	3.0	25.4
Singapore	71.5	0.0	0.0	0.0	45.5	100.0	100.0	31.3	69.7	17.3
Thailand	18.8	34.0	6.8	7.8	12.7	98.9	63.8	23.4	6.1	9.1
Vietnam	7.8	19.7	16.4	44.6	6.1	82.2	29.5	5.8		6.7
China	16.6	37.8	11.6	18.4	8.1	99.3	48.1	30.1	39.4	0.0
India	6.2	71.1	9.5	18.0	7.6	49.8		0.0	24.2	11.0
Japan	52.0	3.5	2.3	11.0	100.0	100.0	100.0	59.7	100.0	100.0
Korea	11.6	19.2	2.5	1.2	13.7	100.0	100.0	17.3	90.9	35.3
USA	100.0	100.0	8.5	10.0	5.3	100.0	100.0	100.0	78.8	55.9
EU	43.8	34.8	7.3	15.4	7.3	100.0	100.0	1.48–4.04	47.3	85.5
Australia	74.4	94.9	28.3	8.5	9.2	100.0	100.0	53.0	57.6	62.0
New Zealand	49.6	49.0	9.2	71.8	9.1	100.0	100.0	82.1	36.4	56.8

	Grid efficiency	Energy resources and stockpiles	Forest cover	Water availability	Per capita energy-related carbon dioxide emissions	Sulfur dioxide emissions	Worldwide governance Rating	Energy exports	Per capita energy subsidies	Quality of Energy Information
Brunei	90.1	100.0	74.2		0.0		64.6	0.0	0	0.0
Cambodia	35.6	0.0	83.8	4.3	59.9		18.6	0.0	9.7	0.0
Indonesia	66.3	3.8	68.3	56.5	10.2	100.0	27.8	100.0	8.4	100.0
Laos	39.9	0.0	100.0	0.0	100.0		12.1	0.0	7.8	0.0
Malaysia	96.2	6.0	90.5	100.0	1.8		65.5	35.8	3.0	50.0
Myanmar	0.0	1.2	69.0	37.0	77.7		0.0	0.0	1.7	50.0
Philippines	65.6	0.5	31.1	78.3	22.6		41.6	0.5	100	50.0
Singapore	85.7	0.0	0.0	100.0	1.1		91.5	0.9	100	50.0
Thailand	76.9	0.7	37.7	95.7	4.5		53.9	3.6	10.0	50.0
Vietnam	68.7	2.5	57.6	73.9	14.9		34.5	46.1	47.2	0.0
China	80.8	2.8	26.7	69.6	2.8	8.3	33.5	27.9	33.1	100.0
India	26.2	2.2	29.2	67.4	14.1	77.7	48.1	0.3	38.2	50.0
Japan	86.9	0.0	97.4	100.0	1.1	67.3	88.1	0.2	16.1	100.0
Korea	54.8	0.0	92.1	91.3	0.8		75.6	0.0	2.9	50.0
USA	82.1	1.1	44.7	97.8	0.0	0.0	87.5	9.6	1.4	100.0
EU	100.0	1.1	50.4	100.0	1.6		84.6	0.0	3.7	50.0
Australia	81.7	1.7	27.0	100.0	0.0	90.5	95.8	33.2	0	100.0
New Zealand	79.4	0.3	41.6	100.0	1.4	14.0	100.0	1.0	1.4	100.0

Note: The dash "-"indicates data for a particular metric was not available.

Table B5
Energy security performance scores for 18 countries for 2010.

	Total primary energy supply per capita	**Average reserve to production ratio for the four primary energy fuels (uranium, coal, natural gas, and oil)**	**Self sufficiency**	**Share of renewable energy in total primary energy supply**	**Stability of electricity prices**	**% population with high quality connections to the electricity grid**	**Households dependent from traditional fuels**	**Retail price of gasoline/petrol**	**Research intensity**	**Energy intensity**	**Grid efficiency**
Brunei	100.0	6.4	100.0	0.0	100.0	99.7	94.7	100.0	–	8.8	83.4
Cambodia	3.9	0.0	12.0	4.1	100.0	12.6	4.2	6.6	–	50.0	57.1
Indonesia	9.5	8.1	30.1	14.8	9.2	59.2	38.6	44.9	–	12.1	63.6
Laos	0.0	100.0	5.1	100.0	7.7	48.3	0.0	6.5	–	27.2	55.2
Malaysia	29.5	6.3	22.0	9.2	41.3	99.3	100.0	51.9	12.1	16.7	94.5
Myanmar	3.5	4.0	25.3	67.1	0.0	0.0	0.0	29.7	–	12.6	0.0
Philippines	4.9	16.1	9.8	36.5	8.6	88.2	50.5	20.0	–	30.0	56.0
Singapore	41.9	0.0	0.0	0.0	22.8	100.0	100.0	21.6	72.7	14.9	82.8
Thailand	17.4	10.0	10.3	9.1	100.0	99.2	73.7	11.0	0.0	7.5	77.9
Vietnam	7.5	4.0	20.6	39.8	1.5	97.2	35.8	11.6	–	2.1	62.8
China	17.5	9.8	16.2	18.1	–	99.3	49.5	19.5	39.4	0.0	79.5
India	5.9	20.0	12.9	15.8	62.2	61.3	37.2	6.1	18.2	9.0	14.8
Japan	40.7	0.6	3.4	10.9	46.1	100.0	100.0	41.4	97.0	100.0	84.5
Korea	51.1	5.6	3.3	1.3	11.0	100.0	100.0	14.9	100.0	34.1	45.5
USA	77.3	29.5	13.4	11.6	15.3	100.0	100.0	76.1	75.8	57.6	78.8
EU	34.5	15.9	10.3	18.1	9.1	100.0	100.0	0–18.25	40.0	86.0	100.0
Australia	66.3	26.9	40.6	8.3	11.2	100.0	100.0	67.8	60.6	59.5	75.9
New Zealand	45.6	15.7	14.7	78.4	8.5	100.0	100.0	43.2	33.3	54.9	75.3

	Energy resources and stockpiles	**Forest cover**	**Water availability**	**Per capita energy-related carbon dioxide emissions**	**Sulfur dioxide emissions**	**Worldwide governance Rating**	**Energy exports**	**Per capita energy subsidies**	**Quality of Energy Information**
Brunei	100.0	73.8	97.7	100.0	–	74.0	0.0	0	0.0
Cambodia	0.0	81.0	9.3	0.7	–	22.3	0.0	7.1	0.0
Indonesia	4.6	65.9	53.5	8.0	–	37.3	100.0	4.2	0.0
Laos	0.0	100.0	0.0	0.0	–	16.3	0.0	5.9	0.0
Malaysia	10.5	90.1	100.0	34.9	–	58.1	66.8	0.4	50.0
Myanmar	2.0	67.6	32.6	0.3	–	0.0	0.0	1.4	0.0
Philippines	0.6	29.8	79.1	3.3	–	36.6	1.4	100	0.0
Singapore	0.0	0.0	100.0	48.0	–	89.0	0.9	100	50.0
Thailand	0.7	37.7	95.3	17.3	–	46.0	3.5	9.9	50.0
Vietnam	3.0	60.6	86.0	5.4	–	35.8	77.0	32.9	0.0
China	2.8	28.4	74.4	25.3	–	36.6	21.4	11.9	0.0
India	2.6	29.5	72.1	5.7	–	46.2	1.0	12.2	50.0
Japan	0.0	98.4	100.0	47.3	100.0	87.4	0.4	10.6	100.0
Korea	0.0	92.8	95.3	54.2	–	74.2	0.0	2.1	50.0
USA	1.5	45.2	97.7	97.4	14.2	86.4	26.5	1.2	100.0
EU	1.3	51.5	100.0	38.3	–	84.8	0.0	3.1	50.0
Australia	2.3	27.2	100.0	97.9	0.0	95.9	88.6	0.3	100.0
New Zealand	0.6	42.2	100.0	40.4	29.5	100.0	2.7	1.1	100.0

Note: The dash "-"indicates data for a particular metric was not available.

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[9] Endpoints for the 0–100 range were then drawn from extreme transformed values in each period. Since GTZ uses black-market exchange rates for countries with parallel currency rates, Myanmar prices were converted from USD equivalents, as expressed in the GTZ fuel price reports, back to local currency using the black-market rate, while all other countries were converted using historical official exchange rates from Oanda or the Federal Reserve Economic Data (FRED) database.
[10] More specifically, the author created a scoring range for a metric for a given year by subtracting the minimum value (the worst performer) from the maximum value (the best performer). Some values were negative, the author discarded these and converted them to zero. The author then took each data point, subtracted the minimum value, and divided by the range. What resulted was a score for each country anywhere between 0 and 100. The idea was to avoid a scoring system based on arbitrary value judgments and instead rely on one that rooted in actual performance.
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